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USE OF PIGEON PEA (*Cajanus cajan L*) AS SOIL AMENDMENT FOR THE GROWTH, LEAF CHEMICAL COMPOSITION AND YIELD OF WHITE YAM (*Dioscorea rotundata L*)

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ABSTRACT
An experiment was carried out to investigate the use of pigeon pea (*Cajanus cajan*) as soil amendment for the growth and yield of white yam (*Discorea rotundata L*) between 1999 and 2002 at Akure in the rainforest zone of Nigeria.

There were four treatments namely; NPK 15 -15 -15 fertilizer applied at 300kg/ha, poultry manure at 6t/ha, pigeon pea planted at two seeds per hole at spacing of 1m x 0.5m between rows of yam plots (soil amendment) and a control (no fertilizer). The treatments were arranged in a randomized complete block design (RCB) and replicated five times. The initial soil status before planting was analyzed and each plot size is 4m x 4m ($16m^2$).

The growth parameters recorded for the yam were vine length (cm), leaf population and stem girth (cm). At harvest, yam tuber weight (kg), tuber length (cm), tuber girth, root length and seed yield of pigeon pea plants were determined. Leaf and soil N, P, K, Ca, Mg, pH and Organic matter contents were also analyzed at the end of the experiment.

The results showed that there were significant ($p>0.05$) increases in the vine length, leaf population, stem girth, tuber weight, tuber length, tuber girth, soil and leaf N, P, K, Ca, Mg, pH and O. M of white yam cultivated under the different fertilizer treatments compared to the control treatment.

Pigeon pea plants used as soil amendment increased yam tuber weight, tuber girth and tuber length by 29.4%, 14.5% and 24.02% respectively compared to NPK fertilizer. While poultry manure increased the same yield parameters by 84%, 68.60% and 89% compared to control treatment respectively.

Pigeon pea plants used as soil amendment also increased the soil pH, O.M, K, Ca and Mg by 28%, 30%, 95% and 89% respectively compared to the NPK fertilizer treatment. In-addition pigeon plants produced 2600kg/ha of edible seeds (2.6t/ha) which gave it a great comparative advantage over the use of poultry manure and NPK fertilizer as soil amendment.

KEYWORDS : Pigeon pea, soil amendment, growth, leaf chemical composition, yield and white yam.

INTRODUCTION

Yam (*Dioscorea spp*) is a tuber crop belonging to the family *Dioscoreaceae* and it is a tropical crop with many species originating in South east Asia and was brought to West Africa in the 16^{th} century. Among the species of yam is white yam (*Dioscorea rotundata*) which produces edible tubers.

Yam is an important crop to man and his environment because it serves as source of food to man and his livestock, provides starch for industrial use and generates income to farmers (Coursey and Hay, 1980).

Despite the enormous benefits of yam to man, the optimum production of the crop is still far below the demand of the populace because of continued decline in fertility of tropical soils. Efforts to increase the soil nutrient status through the use of inorganic fertilizers (Urea and KCl) for optimum yield of yam have been carried out by Hughunchi (1988), Adetoro and Folorunso (1995). Although, good yields were obtained by these researchers, however, some production problems associated with the use of these inorganic fertilizers such as poor storage of harvested yam tubers, poor pounding quality of yam paste from cooked tubers which have led to loss of faith in the use of inorganic fertilizers by farmers (Agboola, 1982b).

Therefore, the use of plant and animal residues for the growth and yield of yam and other crops had been advocated because of their low cost and availability (Agboola, 1974), Kogbe (1976) and Moyin-Jesu (2002). Nevertheless, the high quantities of the plant and animal residues required to fertilize the soil and the intensive labour requirement in their application did not encourage wider adoption by farmers.

The quest to find answers to the above mentioned research problems prompted the need to look inwards for alternative sources of biological fertilizers using the traditional leguminous shrub crops such as pigeon pea (*Cajanus cajan*) and long yam bean (*Sphenostilis stenocarpa*) to enrich the fertility of the soil grown to arable crops, compatible with the farming systems, provide source of food for the farmer(s) and the livestock.

Having reviewed literature extensively, there is scarcity of research information on the use of pigeon pea (*Cajanus cajan*) as soil amendments to increase the soil fertility, growth and yield of yam. Hence, the objectives of this study are as follows.

(i) To determine the effectiveness of pigeon pea with the conventional fertilizers (poultry manure and NPK fertilizers) as soil amendments on the growth and yield of yam.

(ii) To determine their influences on the leaf and chemical composition of yam plots after harvesting.

(iii) To determine the comparative advantage of pigeon pea plants over the convectional fertilizers in term of cost/benefit ratio of farmers.

Theoretical framework for the research

For a proper interpretation of the research findings, the following theoretical position is being taken. Todaro (1985) advanced three core values of development life sustenance, self-esteem and freedom from subservience. His argument is that a people without sufficient means of life sustenance (i.e food and income) will not have self esteem and will consequently remain subservient.

This position is important for us in Nigeria where high status of interest groups morbid loyalty and kinship hold sway in official institutions. Most formal agricultural establishments are created to serve powerful interest and most farm inputs (fertilizers, agrochemicals and seeds) are out of reach of the poor resource and low-income status farmers due to the prevalent scarcity and high cost of purchase.

Therefore, adapting alternative methods of fertilizers such as utilizing organic waste and bio-fertilizer plants such as long yam beans, pigeon pea; cowpea and ground nut for sustainable agriculture must be pursued, vigorously. This is environmentally compatible with the farming system, locally sourced and cheap.

MATERIALS AND METHODS

Field Eperiments

The experiments were carried out at Akure in the rainforest zone of Nigeria and the soil is sandy clay loam, skeletal, *kaolinitic, isohyperthemic oxic paleustalf (Alfisol)* or *Ferric Luvisol* (FAO).

The site had been continuously cropped to cereals and tuber crops for 10 years while the two experiments were conducted between October 1999 and March 2001, and between October 2001 and January 2003 on the same site.

The annual rainfall of the study area is 1300mm and it is well distributed throughout the year while the annual temperature ranged between 22^{o}C and 28^{o}C. These climatic conditions are considered adequate for growth and yield of white yam.

The land was cleared, ploughed, harrowed and ridged. The plots were land out at 4m x 4m (16m^{2}) and yam sets prepared from white yam variety (*Dioscorea rotundata* L) were planted in early November each cropping year in to the plots at a spacing of 1m x 1m. The plots were mulched immediately to prevent scorching and decay of the planted yam sets by heat.

There were four treatments namely poultry manure, pigeon plants, NPK 15 -15-15 fertilizer and a control (no fertilizer, no manure), replicated five times and arranged in a randomized complete block design. The poultry manure was applied at 6 tha^{-1}, NPK 15 – 15 – 15 fertilizer was applied at 300kg/ha, pigeon pea beans were planted at two seeds per hole at a spacing of 1m x 0.5m between the middle rows of yam plots and the unfertilized or control treatment did not receive any fertilizer nor manure nor pigeon pea plants.

Manual weeding operation was first carried out in the third week after sprouting and it continued at every three weeks interval until the maturity of the crop. Individual staking of the yam vines was done in the second week after sprouting in early March 2001 and 2002 and the mulching materials were removed in each cropping year when the rain was steady.

The young yam vines were trailed on the stakes to prevent vines from creeping on the soil and proper drainage channels were made to prevent applied treatments from being washed away by rain water. The yam vine length (cm), leaf population and stem girth (cm) were measured at weekly interval beginning from two weeks after application of treatments till 12 weeks after sprouting.

Harvesting of the yam tubers was done at 32 weeks after sprouting and the following yield parameters were taken such as yam tuber girth, tuber length (cm) and tuber weight (kg). The harvesting of the pigeon yam bean pods started in November to January ending each cropping year and the final weight of the shelled grains were measured and recorded (kg) for each experiment. At end of the harvesting, all the pigeon pea plants were uprooted before the second experiment.

Soil Analysis Before the second experiment.

The samples of the surface (0.15cm)soils used for the experiment were collected, air-dried, sieved with 2mm sieve and utilized for routine soil analysis. The particle size distribution was determined by the hydrometer method (Bouycous, 1951). The soil pH (1.1 soil/water and 1.2 soil/0.01M $CaCl_2$ solutions using a glass/calomel electrode system (Crockford and Nowell, 1956).

The organic matter (O.M) was determined by the Walkley and Black (1934) while the exchangeable bases (K, Ca, Mg and Na) were extracted with 1M NH_40AC pH7 and the amount of K, Ca and Na were determined on the flame photometer using appropriate element filters. The Mg content in the extract was read on atomic absorption spectrophotometer (Jackson, 1958). The exchangeable acidity (H^{+} and AL^{3+}) was measured from 0.01M KCl extracts by titrating with 0.1M HCl (McLean, 1965) while percent N was determined using the microkjedal method (Jackson, 1964).

Available P extracted using Bray P1 *extractant* and the extracts measured with Murphy-riley blue method (Murphy and riley, 1962) on *spectronic* 20 at 882Um while the soil bulk density was determined using core method (Ojeniyi, 1985).

Soil Analysis after the Experiment

At the end of each experiment, soil samples were taken from 0.15cm depth from each treatment plot, air-dried, sieved and analyzed for soil pH, N, P, K, Ca, Mg and O.M, and soil bulk density and described earlier.

Collection, Processing And Analysis of the Treatments used

The poultry manure was collected from over 10,000 poultry birds of Rhode Island breed in the livestock unit of Federal College of Agriculture, Akure. The pigeon pea bean seeds were obtained from over five (5)hectares farm in the institution while NPK 15 – 15 – 15 fertilizers were purchased from Ondo State Agricultural inputs and Supplies Company and it is of high grade. (240 – 240 – 240)

The poultry manure was stacked to allow for proper mineralization processes while the pigeon pea beans seeds were soaked in an 100 ml 0.01M H_2S0_4 acid solution for 30 minutes to weaken the hard seed coat for quick germination.

The determination of the nutrients in the poultry manure was done using wet digestion based on 25 – 5 – 5 ml of HNO_3 - H_2SO_4 – $HCIO_4$ acids. The filtrates were collected for the amount of % P, K, Ca and Mg. The % P was evaluated using vanadomolybdate colorimetry and read on spectronic 20 while the % K, and Ca were read on flame photometer and Mg was determined on atomic absorption spectrophotometery. The % N was determined by microkjedahl method (Jackson, 1964) while the nutrients composition of NPK 15 - 15 – 15 fertilizer was obtained from the manufacturer's label.

Leaf Analysis of the Yam/Plant

At 19 weeks after sprouting, leaf samples were taken from the top, middle and lower parts of the yam crop in each treatment using secateurs, properly cleaned, milled into smaller pieces and dry ashed in a muffle furnace for 6 hours 450^0C. The ash was made into solution, filtered and the filterate was analyzed for N,P,K, Ca and Mg.

The % N was determined using micro-kjedahl method (Jackson, 1964) while the P content was determined using vanado-molydate *colorimetry* and read on *spectronic* 20 at 442Um. Ca contents were determined on flame photometer using appropriate filters while the Mg content was read on atomic absorption *spectro-photometer*.

The data obtained from the means of the two experiments for the growth and, yield parameters, leaf and soil chemical composition were analysed using ANOVA F-test and the overall treatment mean effects were compared using Duncan Multiple Range Test at 5% level.

RESULT

Initial Soil Analysis Before Planting Yam

Table 1 presents the soil physical and chemical properties before planting of yam. The soil is acidic (pH 5.60) and very low in organic matter. The low organic matter content of the soil also reflected in the low values of soil N,P,K,Ca,Mg and Na which were below 10mg/kg P, 0.20 mmo/kg K, Ca, Mg and Na (Agboola and Corey, 1973) and 0.15% N (Sobulo and Osiname, 1981) considered as soil critical levels for optimum crop production in south western Nigeria. The soil density is 1.60g/cm^3

Chemical Composition of the Organic Material

Table 2 presents the chemical analysis of the poultry manure and NPK fertilizer used for the cultivation of yam. The poultry manure had values of % N,P,K,Ca,Mg,Fe,Cu,Mn,Zn and Na while the NPK fertilizer had high values of N,Pand K only and lack Ca,Mg,Na,Fe,Cu, Zn,Mn and Na. Pigeon pea plant fixed 224kg/ha, 4.7%P, 3.2%K,).90%Ca, 1.11%Mg and 0.20%Na (Boonche and Anecksamphant, 1993).

The growth And Yield Parameters Of Yam Under Different Treatments
Table 3 presents the values of leaf area, vine length, leaf population and stem girth, tuber weight, tuber length and tuber girth of while yam under the different fertilizer treatments. There were significant increases ($P<0.05$) in these parameters of yam compared to the control treatment. The pigeon pea treatment increased the yam vine length by 28.13% compared to the poultry manure while NPK fertilizer and pigeon pea treatments increased the yam vine length by 80.70% and 80.67% respectively compared to the control treatment.

The pigeon pea plants treatment increased the leaf population of white yam by 19% and 67% compared to the poultry manure and control treatments while it also increased the stem girth of white yam plant by 38% and 90% compared to the poultry manure and control treatments. The NPK fertilizer treatment increased slightly the stem girth, leaf population and vine length of white yam by 3%, 12% and 2% respectively compared to pigeon pea treatment.

The pigeon pea treatment increased the yam tuber weight (Kg/ha), tuber girth and tuber length by 29.4%, 14.5% and 24.0% respectively compared to NPK 15 – 15 – 15 fertilizer. It also increased these parameters by 31%, 28% and 18% respectively when compared to the poultry manure treatment. Pigeon pea plant increased the tuber weight of yam by 89% compared to the control treatment.

Leaf chemical Composition of Yam Under Different Fertilizer Treatments
There were significant ($P<0.05$) increase in the leaf N,P,K,Ca, and Mg under the fertilizer treatments compared to the control treatment (Table 4). The pigeon pea plants increased the leaf P, Ca and Mg of yam by 7%, 93% and 91% compared to the NPK fertilizer, however NPK fertilizer increased slightly the leaf N and K by 5.2% and 21.96% compared too the pigeon pea poultry. The poultry manure treatment had the best yam leaf N and P contents when compared to other treatments.

The pigeon pea plant increased yam leaf N,P,K,Ca and Mg by 48.24%, 73.4%, 70%, 4.3% and 68.8% respectively when compared to the control treatment.

Soil Chemical Composition of Yam plot After Harvesting
There were significant increases ($P<0.05$) in the soil pH, O.M., N,P,K,Ca,Mg,. and bulk density compared to the control treatment (Table 5). The pigeon pea reduced most the soil bulk density (B.D) by 21% and 20% respectively compared to the NPK fertilizers treatment and control. The pigeon pea plant also increased the soil pH, O.M,K,Ca, and Mg by 28%, 87%, 30.50%, 95% and 89% respectively when compared to the NPK fertilizer treatment. However, NPK fertilizer increased slightly the soil P by 10% compared to pigeon pea plant. The pigeon pea plant produced higher values of soil pH,O.M, N,P,K, Ca, and Mg than that of poultry manure treatments.

Comparative Advantage of Pigeon Pea Plant as Soil Amendment
Table 6 presents the data on the comparative advantage of pigeon pea plant as biofertilizer plant over the convectional organic and inorganic fertilizer (poultry manure and NPK fertilizer) in the fertilization of yam crop. The pigeon plants produced 2.60t/ha (2600 kg) of pigeon pea seeds, in-addition, to the 4886.20kg/ha of yam tuber weight which the use of poultry manure and NPK fertilizer could not produce. The cost benefit ratio of using pigeon pea plant as soil amendment for yam production produced $5,016.20 for the farmers instead of $3,433.00 and $3363.50 produced by poultry manure and NPK fertilizer for yam yield only. The farmers would earn more by 32% and 33% in monetary gain by using pigeon pea as soil amendment for yam production compared to the poultry manure and NPK fertilizer.

DISCUSSION
In the control treatment (no fertilizer, no pigeon pea plant), the least values of growth and yield parameters such as vine length, leaf population, stem girth, tuber weight, tuber length and tuber weight of white yam compared to that of NPK fertilizer, poultry manure and pigeon pea plants could be due to the initial low nutrient status of the soil before application of the fertilizer treatments. This observation also supported the

views of Agboola (1982a) who had reported poor growth and yield responses in soils not fertilized. The low soil nutrients status also reflected in the least values of yam leaf N,P,K,Ca and Mg; soil pH, N,P,K,Ca,Mg and O.M. The low organic matter status (Agboola and Corey, 1973). The low organic matter status would have also contributed to the initial high bulk density of 1.58g/cm^3 which was further increased to 1.60 and 1.63g/cm^3 under the control and NPK fertilizer treatments respectively as a result of continuous cultivation.

The significant increases in the growth and yield of white yam due to application of poultry manure, use of pigeon pea plants and NPK fertilizer could be adduced to increased availability of nutrients in the soils. The application of poultry manure and use of pigeon plants increased soil organic matter, N,P,K, Ca and Mg status and reduced soil acidity. Soil acidity (low pH) is known to affect the yields of crops adversely through inhabitation of nitrogen fixation (Aduayi, 1980).

The highest nutrient contents (Soil organic matter,N,P,K, Ca and Mg) supplied by the pigeon pea plant into the soil were responsible for shoot, and yield development. K had been reported to encourage photosynthesis and tuber formation in yam Adu-Daaph et al, 1994. This could explain why the pigeon pea plant produced the best values of yam tuber weight (kg/ha), tuber length and tuber girth compared to NPK, poultry manure and control treatments. Pigeon pea plant is a legume which fixes N into soil and increased the level of SOM. For- instance, Boonchee and Anecksamphant 1993) reported that pigeon pea plant fixed into soil 224kg/ha symbiotic N, 4.7%, 3.2%K, 0.90%Ca. The leaf liter and canopy of the pigeon pea plant could be responsible for the responsible for the reason why it reduced most the soil bulk density.

The reduction in the soil bulk density by the use of pigeon pea plant should have positively influenced other soil physical properties such as aeration, water infiltration and uptake. Thus, the improvement of soil physical condition is consistent with the work of Woomer and Muchena (1993) which reported that continuous productivity of tropical soils is associated with maintenance and improvement of soil physical characteristics.

Whiteman *et al*, (1985) reported that pigeon pea (*Cajanus cajan*) has been considered a potential crop because of its adaptability to semi-arid environments, tolerance to low soil fertility and capacity to recycle nutrients. The use of pigeon pea plant reduces the rate of erosion, weed competition and supplies nutrients of the soil and this observation agreed with the work of Agboola (1986) which reported that the use of fast growing perennial leguminous crops such as pigeon pea intercropped with other crops reduced the impact of heavy rainfall on soils and assisted in soil fertility improvement. The increase in vegetative growth of white yam such as vine length, stem girth and leaf population under pigeon pea plants compared to that produced by poultry manure and NPK fertilizer could be attributed to the ability of the roots of pigeon pea plants to fix nitrogen into the soil. This observation agreed with the work of Boonche and Anecksamphant (1993) who reported that roots of nitrogen fixing crops such as legumes have nodules, where nitrogen fixation takes place. They stated further that pigeon plant fixed 224kg/H/ha/yr into soil, thus, enhancing its use for soil fertility maintenance.

The reduction in the SOM of plots fertilized with NPK fertilizer adversely affected the Ca and Mg contents of the soils and this could be due to the high P and K in such soils which negatively influence the Ca and Mg availability because of high K/Ca, P/Mg and K/Mg ratio. The implication is that high soil K would result into nutrient in balance as reported by Bear, (1950).

The comparative advantage of pigeon pea plant as soil amendment compared to the poultry manure and NPK fertilizer by providing additional food and income for farmers could be the major ways of improving farmers' standard of living of food security. Mapfumo *et al*, (1998) reported that pigeon pea grain contains an average of 22% crude protein and has a high nutritional value for both humans and livestock. Ali(1996) also reported that in the semi-arid tropics of Asia pigeon pea and soya bean-based systems are rapidly replacing other systems because of higher monetary returns.

Agboola (1982c) further reported that the major reasons why farmers could not adopt the use of green manure such as *calapogonium* and *mucuna* for soil fertility maintenance was that it was labour intensive and farmers did not usually get food or money in return for their cultivation. He suggested that the use of fast growing shrub legumes which would fertilize the soil, provides food and income for the farmers would be advantageous. Therefore, the use of live pigeon pea plants as soil amendment for the production of yam has justified the above assertion by improving the soil and leaf N,P,K,Ca and Mg, soil pH and SOM, provides additional income and food for the farmers.

For-instance, the 2.6t/ha of pigeon pea seed yield under pigeon pea plants treatment yielded $5016.00 compared to $3433.00 and $3362.00 estimated on yam yields under poultry manure and NPK fertilizer treatment Table 6).

However, the cultivation of traditional legumes such as pigeon pea, lima beans and long-yam beans by farmers had gone down drastically such that these crops were nearly going into extinction. There is need to evolve a comprehensive extension package on production of legumes such as pigeon pea as a direct solution in soil fertility management and as a component of food security. Ahmed *et al* (1996) also reported that farmers have now identified the need and potential of pigeon pea as an intercrop with maize, yam and sorghum.

The cultivation and use of traditional legumes such as pigeon pea and lima bens as soil amendments for food crops would aid bringing them back into commercial production by farmers instead of the convectional legumes produced from research centers which encouraged heavy use of agrochemicals because they were easily suspectible to pests and diseases attack. The use of pigeon pea plant as an amendment for yam crop as reflected in the highest values of tuber weight, tuber length and girth showed that it was compatible with food crops as an intercrop. This observation agreed with the work of Adeyemi (1999) which reported yield advantages in cocoyam/maize/cassava intercrop.

CONCLUSION

The researcher work has identified that the use of fast growing legume such as pigeon pea as soil amendment increased the yam vine length, stem girth, leaf population, tuber weight, tuber length and girth; leaf and soil N,P,K, Ca and Mg: soil pH, SOM and decreased soil bulk density. Therefore, the use of pigeon plant as biological fertilizer source for yam production could substitute for 300kg/ha NPK 15 – 15 – 15 fertilizer and 6t/ha poultry manure.

This recommendation agrees with fact that pigeon pea plant is environmentally compatible with the farming system in the tropics, provides additional source of food and income for poor resources farmers. In-addition, the high cost of purchase, scarcity of inorganic fertilizers and the labour intensive nature of gathering high quantities of manure for crop production did not help farmers in achieving sustainable food production.

The versatility of pigeon pea (Protein source, fodder and fuel wood) can potentially benefit a wide range of farmers but the successful adoption of pigeon pea and other legume based technologies may largely depend on dissemination of information through extension approaches to stakeholders on legume technology.

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Table 1: Soil Chemical Analysis Before the experiment

pH		Organic matter	N	P	Exchangeable bases				Bulk density
H_2O	$CaCl_2$	%	%	mg/KG soil	K	Ca	Mg	Na	
					---------- Mmol/kg soil --------				
5.60	5.20	0.43	0.08	6.62	0.08	0.10	0.13	0.12	1.58

Table 2: Chemical Composition of the Organic Fertilizer Used for the Experiment

Organic	N	P	K	Ca	Mg	Na
	%					
Poultry Manure	3.90	0.75	0.48	0.54	0.35	0.09
* Pigeon pea plant	224 kg/ha (Symbiotic N fixed)	4.7	3.2	0.90	1.11	0.20

* Source: Bonchee and Anecksamphant (1993)

Table 3: The Growth and Yield Parameters of Yam Crop Under Different Fertilizer Treatments

Treatments	Vine Length (cm)	Stem girth (cm)	Leaf Population +	Tuber Weight kg/ha	Tuber Length (cm)	Tuber girth (cm)
Control	42.18a	0.38a	12.38a	536.10a	9.78a	1.00a
NPK 15-15-15 Fertilizer	218.84c	3.16c	42.46c	3362.50b	26.14b	7.20b
Poultry manure	191.74b	2.16b	30.26b	3433.10c	31.04c	9.32c
Pigeon pea Plant	218.30c	3.49c	37.38c	4866.20	36.26d	15.72d
LSD (0.05)	5.50	0.70	2.50	5.00	3.70	2.10

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level.

Table 4: Leaf Chemical Composition of Yam Crop Under Different Fertilizer Treatment

Treatments	N	P	K	Ca	Mg
	%				
Control(no fertilizer)	1.03a	0.5a	0.4a	0.10a	0.10a
NPK 15-15-15	2.10b	1.75b	1.73d	0.15a	0.13a
Poultry Manure	2.30c	1.96cd	1.10b	0.25b	0.26b
Pigeon pea plant	1.99b	1.88c	1.35c	0.28c	0.32c
LSD (0.05)	0.10	0.12	0.20	0.10	0.06

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 5% level

Table 5: The Soil Chemical Composition of Yam Plot Under the Different Fertilizer Treatments after Harvesting

Treatments	Bulk Density g/cm^3	pH	O.M %	N mg/kg	P	K mno1/kg	Ca Soil	Mg
Control	1.60c	5.10a	0.24a	0.04	3.80a	0.06a	0.04a	0.07ab
NPK fertilizer	1.63cd	5.13a	0.36b	1.42c	29.30d	0.94b	0.03a	0.02a
Poultry manure	1.36b	6.70b	2.40c	1.34b	24.20b	1.33c	0.75b	0.50c
Pigeon pea plants	1.28a	7.10c	2.70d	1.36b	26.30c	1.35cd	0.83c	0.63d
LSD (0.05)	0.10	0.30	0.20	0.06	1.70	0.30	0.05	0.12

Treatment means followed by the same letters, within each column are not significantly different from each other using Duncan Multiple Range Test (DMRT) at 9% level.

Table 6: Comparative Advantage of pigeon pea Bio-Fertilizer Over the Convectional Organic and Inorganic Fertilizers in Term of Utility Parameters.

Treatments	Yield t/ha of pigeon pea	Cost- benefit ratio
Pigeon pea bio fertilizer	2.60	$5016 ** (Pigeon pea seeds + yam tuber yield)
Poultry manure	-	$3433 * (yam yield)
NPK 15-15-15	-	$3362 * (yam yield)
Control	-	

* 1kg of pigeon pea seeds = ₦50($0.5)
2.6t/ha (2600kg) = $150.1
*Yam price $4866.20/ha)
1 kg of yam tuber = $1.00